MDE Product Development Team
April FY13 Monthly Report
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(Compiled and edited by S. Benjamin and B. Johnson)

Executive Summary

Task 1: Improve turbulence guidance from NWP forecasts

- RAP summer 2013 configuration implementation completed and running smoothly on Jet (Boulder, RAP primary cycle) and Zeus (Fairmont WV) supercomputers and feeding HRRR. Changes include
  -- use of global ensemble information within GSI-based hybrid assimilation procedure for RAP
  -- improved 9-level version of Smirnova Land Surface Model
  -- evaluation and decision to use specially adapted version of MYNN boundary layer scheme in place of current MYJ scheme
  -- improvements to RAP radar-based hydrometeor building and clearing
- RAP version 2 upgrade at GSD complete (including March-April 2013 changes under previous bullet) and increasing the improvement in upper-air wind/temp/RH forecasts over RAP-NCEP. The same is true for surface moisture and precipitation forecasts.
- RAPv2 - ESRL use of hybrid/ensemble data assimilation (with 80-member GFS global ensemble) to specify background error covariance information for real-time parallel RAP marks major step forward, significantly improves RAPv2
- Current upgraded RAP version 2 code built at **NCEP** on new WCOSS computer; quick progress on testing gives promise of initial parallel testing in near future and possibly accelerated pre-implementation testing and implementation by NCO (now proposed for early FY 2014 after NCEP implementation moratorium is lifted).
- Three real-time parallel RAP cycles (with extensive verification of each) running on Zeus NOAA research supercomputer located in Fairmont, WV to evaluate further likely enhancements to RAP data assimilation / model system (all updated after RAP-ESRL-primary code freeze)
- Ongoing evaluation of refined cloud analysis procedure [with selective use of Effective Cloud Amount ECA) parameter provided by the CLAVR-x (Clouds from AVHRR Extended) satellite data.
- NCEP making progress on NAM and NAM-nest
- Operational RAP including RAP GSI component successfully ported to new WCOSS machine

Task 2: Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

- Final modification to 2013 run configuration completed for RAPv2 / HRRR including enhancement for effectively hydrometeor clearing and a key improvement to run the 3-km variational assimilation on GSI.
- Monitoring and evaluation of HRRR reliability and forecast skill and examination of RAPv2 performance for convective related fields (near surface temperature and dew point and sounding structure).
- Installation of HRRR test code infrastructure on NCEP WCOSS computer in anticipation of NCEP implementation, possibly early in calendar year 2014.
- Updates and testing of RTMA code package and placement of it under SVN code repository management.

Task 3: Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

Upgraded physics configuration now running in RAPv2 at GSD, code compiled at NCEP

- 9-level RUC land-surface model: improvement in surface wind forecast and 2-m temperature forecast
- GSD/Olson version of MYNN boundary-layer scheme: improvement in low-level wind forecasts
- Continue use of Grell G3 parameterization of deep convection from WRFv3.2.1.
- Integration of bug correction into RAP/ WRF regarding lack of radiation effects from snow mixing ratio in atmosphere, which has been contributing to a daytime warm bias in the RAP and HRRR at the surface.

NCAR/RAL making excellent progress on aerosol-aware microphysics

Task 4: Develop convection-ATM-specific improvements to guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA

- Real-time, frozen RAPv2/HRRR system running successfully with gridded field dissemination, real-time web display of graphics and verification of many forecast fields.
- Ongoing monitoring of RAPv2/HRRR system with regards to reliability and forecast performance.
- Successful initial test of HRRR “failover” capability to use feed from Zeus instead of Jet during scheduled Jet downtime on April 23-24.
- Examination of enhanced verification of HRRR convective forecasts, including VIL and echo-top.

Task 1: Improve turbulence guidance from NWP forecasts

Improving turbulence forecast quality involves efforts to improve initial conditions for the RAP and NAM (and HRRR and NAM nests) and to improve the models (WRF-Advanced Research WRF (ARW)-RAP and NOAA Environmental Modeling System (NEMS)- Nonhydrostatic Multi-scale Model – B (NMMB)).

Tasks will include:

- Continuing evaluation of RAPv2 toward early 2014 implementation at NCEP, incorporating changes developed in 2012 and early 2013.
- Collaborating on developing & testing best approaches for use of hybrid/EnKF/3DVAR within common GSI coding structure.
- Collaborating on developing and testing physics schemes between WRF and NEMS' physics layer.
- Negotiating Data Mining List priorities with NCEP Central Operations and external points of contact associated with the most desirable new sources of observations. (NCEP and ESRL)
- Continuing final testing of RAPv3, including initialization of the HRRR.

ESRL

Regarding the NCEP RAP

The operational RAP at NCEP continues to run without any technical problems, including post processing. The RAP continues to show improved reliability over the previous RUC at NCEP; March UniPost fix to avoid crashes due to spurious decrease in height with decreasing pressure has worked flawlessly.

As noted in our FY13Q2 report, work began at NCEP last quarter toward implementation of RAP on NCEP's new WCOSS computer. The current operational RAP was successfully run on WCOSS last quarter. Facilitated by NCEP after Stan Benjamin's RAPv2 presentation to the NCEP Central Computing System Science Quarterly on 9 April, progress accelerated during April. The RAPv2 executable based on the GSD RAP-primary code were successfully built on WCOSS and new versions of fixed files needed to run RAPv2 were ported to NCEP. Prospects now appear good that a parallel RAPv2 cycle will be running on the WCOSS machine within the next several weeks toward a possible NCEP operational implementation of RAPv2 by early FY2014.

Regarding the ESRL RAP

In our last quarterly report we described the summer 2013 RAP and HRRR configurations and the path to their completion. A list of the configuration changes from the summer 2012 versions of the RAP and HRRR can be found here. These form a new baseline for testing of candidate future enhancements in RAP and HRRR, which began during April, using the three development RAP cycles on the Zeus computer. RAP-dev1, identical to the RAP-primary running on the Jet computer, is temporarily reserved for examining the impact of special dropwindsonde data to be collected over the western CONUS during the Mesoscale Predictability Experiment (MPEX), 15 May through 15 June. These data will be made available to the RAP-dev1 cycle, but withheld from the RAP-primary. The Zeus RAP-dev2 cycle is currently set aside for further testing of the Grell-Freitas convection parameterization. RAP-dev3 is being used to examine the impact of bias correcting temperatures from aircraft observations [more on this below?

Since the RAPv2 summer 2013 configuration was put into the RAP-primary in early April, two snow-related issues have arisen. One of these was excessive snowfall in a narrow band near Omaha on 2 May in association with a strong, slow-moving front. Diagnosis of this has revealed a special set of circumstances related to radar bright-band issues that calls for modification in areas of high reflectivity near 0C: limiting the mixing ratio of snow hydrometeors in the GSI cloud analysis and restricting the magnitude of the temperature tendency during the forward leg of the Digital Filter Initialization. The second is a distinct nighttime cold bias in 2-m temperature in areas of snow cover. This was tied to introduction of the MYNN planetary-boundary and surface layer, and is discussed under Task 3.

Evaluation of the new GSI cloud analysis enhancements including Effective Cloud Amount (ECA) from the improved CLAVR-x (Clouds from AVHRR [Advanced Very High Resolution Radiometer] Extended) data from NESDIS continued. While some reduction in RH moist bias in the 600-300 hPa range was achieved from these enhancements while building clouds at all levels from GOES data, we decided to hold off their implementation until after the RAP freeze is over in November, pending more evaluation of thresholds to use in determining areas of partial cloudiness (equivalent to METAR SCT or BKN sky cover) and other considerations implied in switching to the CLAVR data.

Haidao Lin continued his work on obtaining improved results for AIRS satellite radiance assimilation in the RAP.

Other activities, some noted more fully under other tasks, also were undertaken:

- The NCAR WRF developers officially released ~~of~~ WRF version 3.5 on 18 April. This includes a number of contributions by GSD developers: the latest version of the RUC LSM (Smirnova), the Grell-Freitas deep and shallow convection, the MYNN PBL and surface-layer schemes updated through late December (Olson) and the current version of the RAP digital filter initialization (Peckham and Smirnova.
- Retrospective testing for both RAP and HRRR of the impacts of proprietary in situ tower wind data and other special data continues under funding from the DOE Wind Forecast Improvement Project.

NCEP

An alternative initialization in both land surface states and atmospheric conditions was tested with the SREF system to improve performance. Per a request by Jeff Tongue of the Eastern Region WFO in New York, the NARRE-TL (time-lagged ensemble using RAP forecasts valid at the same time) was retrospectively run for an April 24 severe fog case at JFK Airport. This fog event was successfully predicted by NARRE-TL and the WFO wanted to make a good case study of this event. (BinBin Zhou and Jun Du)

The transition of the RAP observation processing codes to WCOSS is complete. The NCO live data tests were completed in April. (Dennis Keyser)

Work continues on improving the RTMA 10-m wind analysis over the major lakes. The initial idea of adding new control variables for lake stream function and velocity potential, and combine them together with the corresponding land variables upon application of the recursive filter turned out to be inadequate. Large gradients along the coastlines were found in the combined control variables, which resulted in unrealistically large wind increments. A complete two-analysis solution that computes over-water and over-land wind increments from the two sets of control variables is now being pursued. (Manuel Pondeca, Steve Levine)

Comparisons of radar data processing were done between the WCOSS machines Tide and Gyre. Operational radar data processing jobs ran on Tide without problems but some radar jobs ran longer than the allowed wall clock time on Gyre. The raw data was found to arrive on Gyre about 30 to 40 minutes later than on Tide (because of a longer circuit path). A set of parallel runs were set up to monitor this problem. Tests of GOES cloud data in NAM versus RAP prepbufr files were begun. In general, NAM prepbufr includes more data than RAP prepbufr within the same dump window. A website was built to monitor reflectivity mosaic, no-qc reflectivity, dual-polarity variables and model forecast reflectivity (http://www.emc.ncep.noaa.gov/mmb/wx22hl/REF/web/html/radar.html). (Shun Liu)

Work continued on moving the GSI package to the new WCOSS computer. Regional GSI jobs failed when running with 250 or more tasks. It was found that the program stopped when trying to use an undefined array and the dimensions from a wrong structure variable were used in the decision on whether to allocate and calculate the arrays. This issue, along with other bug fixes, has been addressed. For a consistent restart capability, the unit of lat/lon variables in the NMMB forecast system input and restart files will be changed from degrees to radians. The corresponding GSI change was done to accept these variables in both units. These changes passed regression testing and were sent to the GSI review committee. (Wan-Shu Wu)

CAPS

In the previous quarter, a regional dual-resolution hybrid DA system for RAP with 3-hourly cycles with conventional data is established. It was found that the 13km forecasts from the dual-resolution hybrid analyses were no better than the 13km forecasts from interpolated EnKF or hybrid analyses performed at 40km grid spacing. The evaluation was limited to 3-hour forecasts before (due to disk spacing issues). This month, the experiments were rerun and forecasts were made up to 21 hours and verification was performed on the fly (to save disk space). The results are somewhat improved, but some variables are still not better. Further comparisons were made between the 40km forecasts from 40km EnKF and hybrid analyses and the 13km forecasts started from the interpolated 40km analyses, and it was found that the RMS errors of the 13km forecasts are larger – this could be the cause of the poor performance of the dual-resolution experiments. The window length differences between the 40- and 13km forecasts, and the high-resolution terrain used on the 13km grid are suspected to be the main causes, and new experiments will be run to isolate the causes.

Additional information on RAP-related tasks

ESRL

GSD continues to make pgrb and bgrb files from the ESRL/GSD RAP-primary (RAPv2) real-time 1-h cycle available from its FTP site for users in NWS and other labs).

NCEP

NCEP maintained real-time availability of SAV and AHP guidance to all vendors from the operational hourly RAP on pressure surfaces via the NWS Family of Services (FOS) data feed and via the FAA Bulk Weather Data Telecommunications Gateway (FBWDTG). (EMC&NCO)

NCEP maintained real-time availability of full resolution gridded data from the operational RAP runs via anonymous ftp access via the NCEP server site at **ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/rap/prod/** and at the NWS/OPS site at **ftp://tgftp.nws.noaa.gov/SL.us008001/ST.opnl/** in hourly directories named MT.rap_CY.00 through MT.rap_CY.23. This includes hourly BUFR soundings and output grids, which undergo no interpolation. Both sites now contain only grids in GRIB2 format **http://www.nco.ncep.noaa.gov/pmb/docs/GRIB1_to_GRIB2.shtml.** Gridded RAP and NARRE [-TL] fields are available on **NOMADS** for the CONUS domain on 13 km grid #130 and the Alaska domain on 11.25 km grid #242. RAP fields are also available for the larger North American domain on 32 km grid #221. A limited set of fields from the RAP runs (and other NCEP models) can also be viewed at **http://mag.ncep.noaa.gov/NCOMAGWEB/appcontroller.** (EMC&NCO)

Verification of RAP

ESRL's verification of the RAP is available from **http://ruc.noaa.gov/stats**. NCEP maintained its capability and provided access to routine verifications of the operational RAP analyses and forecasts. These include grid-to-station verifications versus rawinsonde, surface, aircraft, Profiler, and VAD data computed periodically at NCEP and accessible via NCEP's Mesoscale Modeling Branch website: **http://www.emc.ncep.noaa.gov/mmb/research/meso.verf.html** .

Deliverables	**Delivery Schedule**
Task 1 – Improve turbulence guidance from NWP forecasts	
a. Finalize code for RAPv2 for implementation at NCEP (ESRL, NCEP) • Vigorous effort leading complete package with extensive improvements, summary at: **http://ruc.noaa.gov/pdf/ESRLRAPHRRRchanges2013.pdf**	Mar 2013 **COMPLETE**
b. Complete the testing of the 40/13 km dual-resolution hybrid DA system for RAP with 3-hourly cycles with conventional data (GSD, CAPS) • Initial work completed by CAPS, testing of further enhancements to system. GSD testing and inclusion in RAPv2 of hybrid system with full observational data, using GFS ensemble data. Milestones exceed.	Mar 2013 **COMPLETE**
d. Report on early version of RAPv3 primary cycle at GSD with physics enhancements for initialization of the HRRR. (ESRL)	Dec 2013
e. Report on the optimal configurations for including satellite data in the 40/13 km dual-resolution hybrid system to ensure overall positive impacts of the data (NCEP, ESRL)	Dec 2013
f. Finalize RAP version to initialize experimental HRRR for 2014 real-time use toward operational HRRR (ESRL)	Mar 2014
g. Deliver progress report on development of NARRE (NCEP, ESRL)	Mar 2014

Deliverables	Delivery Schedule
h. Deliver progress report on ensemble/hybrid data assimilation for use in NARRE (ESRL, NCEP)	Mar 2014
i. Subject to NCEP Directors' approval, upgrades to observation processing &/or quality control and/or GSI and/or NMMB systems become Operational at NCEP. (NCEP)	Mar 2014
j. Incorporate physics and dynamics improvements from the user community, GSD, and NCEP into WRF for use in the Rapid Refresh system. (NCAR-MMM)	Mar 2014

Task 2: Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

GSD

April began with the completion of a very intensive work effort culminating with the successful freezing of RAPv2 code and HRRR code for the 2013 warm season evaluation and code transfer to NCEP for RAPv2. As part of this, there was some additional very minor modifications to address two issues: 1) clearing of low-level hydrometeors that are below the radar coverage region when the satellite data indicates clear skies to the ground and 2) a key timing-related improvement to run the 3-km variational assimilation on a coarsened grid, while simultaneously retaining the fine grid for the non-variational cloud analysis. This last step reduced the 3-km GSI analysis run time from ~23 min. to less than 10 min. and was an enabling factor in getting the overall run time for the HRRR (pre-processing, HRRR model, post processing) down to an acceptable level.

Follow-up work during the remainder of the month focused on two areas: 1) monitoring the GSD RAPv2/HRRR system for both run reliability and for forecast performance and 2) installation and test runs of HRRR modules on the NCEP WCOSS computer system. This latter task has involved collaboration with Geoff Manikin of EMC and is an important step toward operational implementation of the HRRR, now tentatively planned for early 2014. The monitoring for forecast skill has involved quantitative examination of HRRR and RAP skill scores and qualitative examination of specific HRRR forecast reflectivity fields and RAP forecast temperature and dew point fields. Results have been mostly positive. Fig. 1 shows a +9h HRRR valid 22z 8 May 2013. This was a very active weather day across much of the country and the HRRR does well capturing many different areas of storms and precipitation.

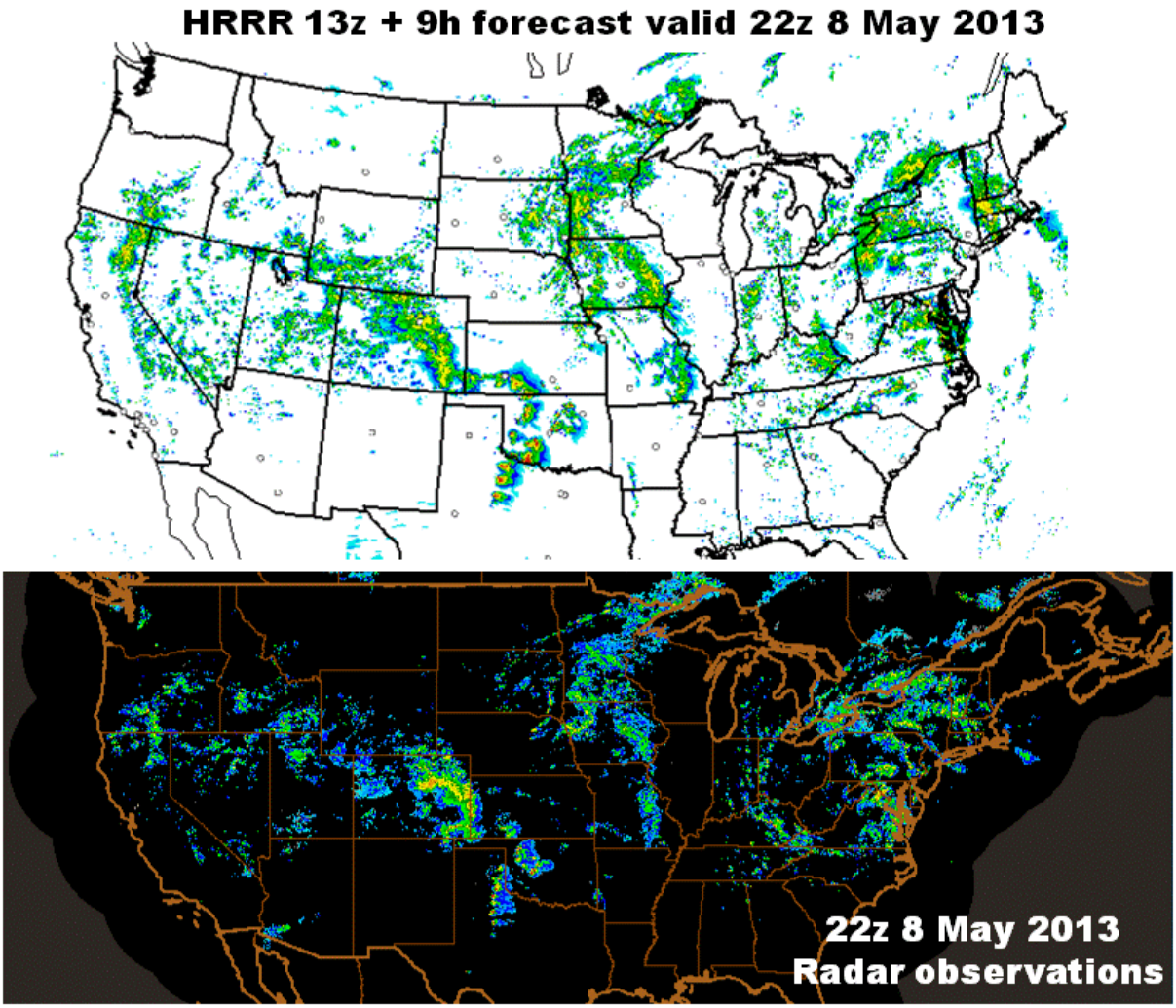

Fig. 1 (top) HRRR +9h forecast reflectivity valid 22z 8 May 2013. (bottom) 22z 8 May 2013 radar observed reflectivity.

A final task related to the code freeze is the restoration of various other real-time model and analysis runs (HRRR-dev, RTMA and RUA) that were suspended during the intensive testing period to free up more cores for retrospective runs. Patrick Hofmann completed additional testing on the RTMA package, optimized the run times and has placed the updated code under SVN repository code management, an important step for managing code development going forward. Run times and core usage for the 3 components of the RTMA are as follows: pre-processor – 2 min. on 1 core, 2DVAR form of GSI – 6 min on 60 cores, postprocessor/grib file generator 3 min. on 12 cores. Thus running the RTMA in real-time every 15 min. will be achievable. Running of the real-time RTMA with 15-min updating has been delayed due to issues obtaining a real-time 15-min feed of surface observations. As an alternative, we have scoped out the work required to create 15-min prepBUFR surface observation files from GSD resident NetCDF METAR and mesonet observation files and will complete this and plan to have the RTMA running in real-time every 15 min. over the next two months.

As reported last month in the quarterly report, an intensive work effort ending in early April was focused on testing and evaluating numerous enhancements to GSD RAPv2 / HRRR data assimilation and modeling systems, both in retrospective experiments and in merged real-time evaluations. Numerous obstacles, both scientific and technical (computer related) were overcome and an extensive package of enhancements to both RAPv2 and HRRR model and data assimilation systems is successfully running and yielding significant forecast improvements from both RAP and HRRR for convection and most other forecast parameters.
A complete listing of the system enhancements can be found at:
http://ruc.noaa.gov/pdf/ESRLRAPHRRRchanges2013.pdf

Note: Due to restructuring of the script and re-writing of key codes (including GSI resolution modification), a 45-min improvement in latency HRRR 15h forecast was realized, now down to 1h 50 min after analysis time.

Also as reported last month, work continues in coordination with EMC and NSSL colleagues on further developing and evaluating HRRR-based Real-Time Mesoscale Analysis (RTMA) and Rapidly Updated Analysis (RUA) products. Good progress has been made for both of these, with prototype hourly updated test systems running in real-time over the past few months (though temporarily suspended to allow for more intensive evaluation RAP/HRRR changes. A report summarizes this work can be found at **http://ruc.noaa.gov/pdf/GSD_RTMA_report.pdf**

NCEP

NCEP EMC and NCO conducted a planning exercise of what the modeling suite might look like on WCOSS Phase 1 and Phase 2. The size of the latter would be enhanced by the Sandy Supplemental funds. This plan incorporated ESRL/GSD along with all other contributors to the NCEP Production suite. NWS Director Louis Uccellini was briefed 28 March. While tentative, these plans called for HRRR implementation on Phase 1 and a HRRR Ensemble (HRRRE), combining multiple runs with configurations of both WRF-ARW and NMMB, on Phase 2. A sizable bank of computing was dedicated on Phase 2 to advanced data assimilation for the convective allowing scales of the HRRRE, likely involving a 4-dimensional version of the current GSI-hybrid-EnKF.

Deliverables	**Delivery Schedule**
Task 2 – Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE	
a. Report on initial tests of 3-km 15-min RTMA cloud / surface analysis for use in frontal diagnostics, CI assessment and other near-surface assessments (ESRL, NCEP) • *Good progress toward 3km RTMA and RUA surface and cloud analyses* • *Successful initial tests summarized in report:* **http://ruc.noaa.gov/pdf/GSD_RTMA_report.pdf**	Feb 2013 COMPLETE
b. Incorporate all assimilation and model changes that affect the HRRR into a frozen version of HRRR (and parent Rapid Refresh) for 2013 real-time use (ESRL) • *Extensive set of enhancements in place and running in real-time experimental GSD RAPv2 / HRRR system*	Mar 2013 **COMPLETE**
c. Provide preliminary 15-min RTMA surface analyses as experimental improved basis for frontal diagnostics and other diagnostics from surface analyses (ESRL, NCEP) **Good progress on code update and SVN repository, but issue obtaining real-time 15-min observation data feed. Work to create this file from GSD in-house NetCDF METAR and mesonet fields scoped out.**	Apr 2013 **Request delay to June 2013**
d. Report on computing resource status on NCEP Central Computing System, NOAA R&D Site A and NOAA R&D Site B with regards to possible implementation of HRRR (NCEP, ESRL)	Jun 2013
e. Complete FY13 internal assessment with revised 3-km HRRR running every hour (ESRL)	Sept 2013
f. Provide revised 15-min RTMA surface analyses as primary basis for frontal diagnostics and other diagnostics from surface analyses for real-time use in 2014 (ESRL, NCEP)	Feb 2014

Deliverables	Delivery Schedule
g. Finalize all changes to the HRRR for real-time use in 2014 (ESRL)	Mar 2014

Task 3: Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

GSD

To summarize from the last quarter report, extensive testing and evaluation of physics options for RAPv2 continuing through January and February into March led to the late March decision on the following physics configuration for RAPv2 used within the WRFv3.4.1 code:

- New 9-level configuration of the RUC land-surface model (RUC LSM)
- Mellor-Yamada-Nakanishi-Niino (MYNN) planetary-boundary- and surface-layer scheme in place of the current Mellor-Yamada-Janjic (MYJ) scheme.
- Continue use of the Grell G3 scheme from WRFv3.2.1.
- Continue use the Goddard short wave and RRTM long-wave radiation schemes.
- Use WRFv3.4.1 version of the Thompson microphysics.

As noted under Task 1, a notable cold bias showed up over areas of snow cover during April and early May. Investigation of this unexpected problem by Joe Olson and Tanya Smirnova led to the discovery that code that uses a special formulation for the roughness length for heat over snow cover (Andreas 2002, *J. Hydromet.*) introduced late last year had been inadvertently deactivated in late March. As a result, the coupling between the cold snow surface and the adjacent atmosphere was too large, resulting in the cold bias. The use of the Andreas formulation was restored in early May.

Test and evaluation of the Grell-Freitas convective parameterization continues. The WRFv3.5 version of this scheme was not deemed superior to the currently used version 3.2.1 of the older G3 scheme due to generally well-placed but insufficient precipitation and upper wind forecasts that were not clearly superior to those obtained using the v3.2.1 G3 scheme. Georg Grell continues to work with the G-F scheme and we are not excluding its use in later versions of RAP.

The use of WRFv3.4.1 by default incorporates the NCAR (Greg Thompson) fix to allow attenuation of incoming solar radiation by clouds in the Goddard short-wave radiation scheme. So this is part of the RAP physics configuration used with the RAP-primary that feeds the HRRR for this summer's convection exercise.

GSD requests deferral of Deliverable 3.c (Request for Change for RAPv2 physics) from May to August 2013. As described earlier under Task 1 efforts, testing is now underway for RAPv2 on the new NCEP WCOSS computer. But this date was inadvertently set too early.

NCEP

Planning continues to assist Greg Thompson with his suggestions to do radiation-microphysics coupling via working more directly with NCEP's RRTM expert Yu-Tai Hou and others at EMC. His suggested changes do not involve the aerosol work already done in his WRF-ARW version, however. Rather, his changes would bypass the internal assumptions of droplet and ice sizes assumed within RRTM and utilize directly computed water/ice radii from the Thompson microphysics scheme instead. Since the versions of RRTM used at NCEP and within WRF have diverged, there is some risk this will be more involved than currently envisioned.

NCAR/RAL

CURRENT EFFORTS: During the month of April, NCAR-RAL completed a suite of WRF simulations using the new aerosol-aware Thompson microphysics scheme, including nine two-dimensional idealized tests and six three-dimensional sensitivity experiments of a 72-hour storm period. All current indications are positive with regard to expected changes to clouds, precipitation, and radiation, and more detailed analysis and preparation of a journal article describing the scheme and test results are ongoing.

FUTURE EFFORTS: Using the new code, we will investigate the sensitivity of aircraft icing due to cloud changes from altered aerosols. NCAR-RAL will work closely with colleagues at NOAA-GSD to transfer and guide code integration, especially more explicit coupling with their existing WRF-Chem model configuration.

PROBLEMS/ISSUES ENCOUNTERED: Conflicts for staff time on other projects remains challenging due to uncertain funding with government sequester, but we will work collaboratively with NOAA to support code integration.

INTERFACE WITH OTHER ORGANIZATIONS:

Alison Nugent (PhD student) and Ron Smith, Yale University

Yaitza Luna (PhD student), Howard University

Antonio Parodi, CIMA foundation, Italy

NCAR/MMM

Deliver a WRF Users' Workshop and WRF Tutorial for the User Community

NCAR began preparing for the next WRF tutorial at its Foothills Lab, which will be July 15–26, 2013. This will include a basic WRF tutorial, a WRFDA tutorial, a WRF-Chem tutorial, and a WRF regional climate tutorial. The tutorial is described at: **http://www.mmm.ucar.edu/events/tutorial_137/index.php**.

NCAR continued the organization of the 14th WRF Users' Workshop. This will be at NCAR's Center Green facility in Boulder on June 24–28. In addition to three days of WRF-related presentations and discussions, it will feature a half-day of lectures on radiation and effects of clouds, ozone, and aerosols. The final day will feature tutorial-type sessions on packages such as WRF-Hydro, NCL, and VAPOR.

PLANNED EFFORTS: NCAR will continue to prepare both the 14th WRF Users' Workshop and the summer WRF tutorial.

UPDATES TO SCHEDULE: NONE

Incorporate Physics and Dynamics Improvements into WRF

NCAR issued WRF major release Version 3.5, and details may be found at: **http://www.wrf-model.org/release.php**. Version 3.5 includes software framework improvements, a new WRF hydrology model, new physics options, new observation types for WRFDA, and WRF-Chem additions.

Jimy Dudhia of NCAR/MMM contributed to the preparations for WRF V3.5 release. He included a fix for the Zhang-McFarlane cumulus scheme from PNNL contributors. That cumulus scheme had been put into WRF in a previous release.

Jimy Dudhia of NCAR/MMM is coordinating work which includes shallow convection and cloud-radiation-aerosol effects. The shallow cumulus scheme is the Deng scheme being developed at
Penn State, and this might go into the next minor release. Greg Thompson (NCAR/RAL) is modifying the Thompson microphysics scheme in WRF to pass hydrometeor information to radiation schemes to enable closer interaction of radiation and microphysics. Lastly, NCAR/MMM visitor Jose Ruiz-Arias (University of Jaen) is working on a new parameterization for WRF to provide information on clear-sky aerosol effects to the RRTMG and Goddard radiation schemes. Both of these aerosol-related scheme modifications are in a timeframe for the next major release.

NCAR/MMM has worked also with NOAA/GSD/ESRL to implement its changes to the RUC land-surface model, the MYNN boundary-layer scheme, Grell-Freitas convective scheme, DFI updates, and other changes also into WRF Version 3.5 so that these changes will also become available to the WRF community.

PLANNED EFFORTS: The development and incorporation of new physics and dynamics for WRF for the RAP will continue through FY13Q3.

UPDATES TO SCHEDULE: NONE

Task 3 – Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE	**Delivery Schedule**
a. Complete initial evaluation of aerosol-aware microphysics in RAP real-time cycling at GSD for its suitability as part of the RAPv3 prototype for 2014 NCEP implementation (NCAR-RAL, ESRL)	Delay until funding restored to NCAR
b. Final model physics code transfer complete to EMC for Rapid Refresh 2 upgrade change package to be implemented at NCEP by spring 2014 (ESRL, NCEP) • Freeze of model physics code for March 2013 version of RAP at ESRL allows this milestone to be met.	Mar 2013 **COMPLETE**
c. Pending NCEP computer readiness and EMC and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit WRF physics code changes as part of upgrade for Rapid Refresh v2 software to NCO (NCEP, ESRL)	May 2013 **Request defer to Aug 2013**
d. Transfer upgraded coupled aerosol-microphysics scheme into a test version of HRRR (NCAR-MMM, ESRL)	Dec 2013
f. Finalize microphysics changes and other physics changes to improve icing forecasts for ESRL version of RAP and HRRR for 2014 real-time use (ESRL)	Mar 2014
g. Report summary of icing probability skill measures by quarter for the year. (NCEP)	Mar 2014

Task 4: Develop convection-ATM-specific improvements for guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA

Current:

Following completion of the RAPv2 / HRRR code updates and freeze in early April, work has focused on monitoring the HRRR, restoring the other real-time product generation packages (suspended for the intensive RAPv2 / HRRR testing and completion of the file failover capability. This failover capability was successfully tested during the April 23/24 scheduled JET downtime with parallel HRRR files from the Zeus HRRR-dev been transferred back to GSD and distributed in real-time. This was completed in spite of a somewhat slow file transfer speed between the EMC computer and the GSD computers. Addition work by ITS personnel to speed up this transfer rate is planned for later this spring.

HRRR Reliability for 0-8 Hour VIL/Echo Tops for March 2013

Note: statistics are lower for April because during the early part of April, Jet and especially Zeus were used extensively for final RAPv2/HRRR testing and code finalization for the code freeze. Reliability has been considerably higher since the code freeze.

Jet
All runs: 68.8%
3 or more consecutive missed runs: 84.9% (most meaningful for CoSPA)
6 or more consecutive missed runs: 93.3%
25 outages of at least 3 hrs. or longer
13 outages of at least 6 hrs. or longer

Zeus
All runs: 34.9%
3 or more consecutive missed runs: 48.1% (most meaningful for CoSPA)
6 or more consecutive missed runs: 58.5%
32 outages of at least 3 hrs. or longer
13 outages of at least 6 hrs. or longer

Combined (Jet or Zeus)
*** Not computed due to extensive testing during early April ***

Planned:
Final work on distribution of HRRR model forecast data to ESRL/GSD from Zeus without using Jet resources, allowing for a completely redundant real-time experimental HRRR system. Requests for dedicated computer reservations on Zeus, to further increase the reliability of the HRRR, will be submitted.

Task 4 – Complete implementation of refined SatCast assimilation for HRRR for real-time use in 2014

Current:
Tracy Smith ported SatCast assimilation code (previously developed for use with the RUC analysis) from the RUC to the RAP (GSI package). The code ingests SatCast IR cloud-top cooling data and maps it into a local heating function that is applied to the RAP fields in a similar manner to the way the RAP assimilates radar reflectivity data. Using a sample IR cloud-top cooling rate data set from a convectively active period in early July 2012, she completed a preliminary 1-day retrospective experiment (control run without the SatCast data and experiment with the SatCast data). Preliminary results indicate that for a scattered thunderstorm situation over the Southeastern U.S., assimilation of the SatCast IR cooling rates leads to a better short-term prediction of small-scale convective systems. Further work is ongoing.

Interact with CoSPA (or other) program partner labs and the FAA

Current:
CoSPA team telecons and e-mail correspondence has occurred in conjunction with issues related to the HRRR code freeze and the resolution of these issues.

Planned:
The CoSPA demonstration period will begin on 17 April, with ongoing communication amongst the teams (ESRL/GSD, NCAR/RAL, and MIT/LL).

Deliverables	**Delivery Schedule**
Task 4 – Develop convection-ATM-specific improvements to guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA	
Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2013 real-time use (ESRL) • Code for revised echo-top / reflectivity diagnostics with revised microphysics implemented in GSD real-time HRRR.	Mar 2013 **COMPLETE**
Conduct baseline testing of the early 2013 HRRR version (ESRL) • Baseline testing of 2013 HRRR version completed as part of code preparation for freeze. Summary of skill score improvements being	Mar 2013 **COMPLETE**

prepared.	
Report on evaluation of new microphysics scheme and associated echo-top and reflectivity diagnostics in ESRL/GSD RAP and HRRR (ESRL) • *Preliminary evaluation completed and summarized in report:* **http://ruc.noaa.gov/pdf/GSD_reflectivity_report.pdf**	Mar 2013 **COMPLETE**
Assess HRRR reliability and provide monthly reporting (ESRL) Reliability statistics are being reported each month	*Apr 2013* **COMPLETE** *(ongoing)*
Report on evaluation of revised WRFv3.4 microphysics for RAP/HRRR for its effects on echo-top and reflectivity in ESRL RAP/HRRR (ESRL)	Mar 2014
Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2014 real-time use of HRRR (ESRL)	Mar 2014
Complete implementation of refined SatCast assimilation for HRRR for real-time use in 2014 (ESRL)	Mar 2014
Report on 2014 baseline testing of the HRRR (ESRL)	Mar 2014